Sea-Based Theater Air & Missile Defense

A 21st Century Warfighting Concept

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Joint Vision 2010, ***Forward…from the Sea***, and ***Operational Maneuver from the Sea*** chart the direction for naval forces in the 21st Century. They collectively envision sea-based power projection that employs naval maneuver, precision strike, superior situational awareness, force protection, and focused sustainment. ***Sea-Based Theater Air & Missile Defense*** proposes a move to fully integrated operations, logistics, and information in implementing this guidance. It offers a conceptual framework and identifies future operational capabilities enabling battlespace dominance through naval power projection and force protection from sea-based forces. ***Sea-Based Theater Air & Missile Defense*** is part of an on-going process to open debate and provide alternatives for future investigation and experimentation.

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Introduction

Future combat operations will place a premium on sea-based power projection and force protection by highly mobile, hard-hitting naval forces. The growing theater air and missile threat is a major challenge to force protection, particularly when it is armed with weapons of mass destruction (WMD). Current stand-alone theater air and missile defense (TAMD) capabilities will be inadequate to protect U.S. forces and critical interests from attacks by theater ballistic missiles, land attack cruise missiles, piloted aircraft, and unmanned aerial vehicles in the future battlespace. This concept describes a framework for developing network-based naval TAMD capabilities to defeat the future theater air and missile threat.

Accelerating changes that are already underway, the future of naval TAMD breaks sharply from present practice, capabilities, and organization. Naval TAMD will be a fundamentally different undertaking by 2015, responding to emerging threats, political and strategic factors, transformational technologies, and changing force structure. The principal tenets of future, sea-based TAMD hold that:

- Sea-based force protection is an integral element of future operations, especially when naval forces are pursuing objectives deep inland.
- Force protection against the emerging theater air and missile threat ensures U.S. forces can get where they need to go, stay there until their job is done, and get out safely.
- Naval forces will integrate their capabilities against the theater air and missile threat as a *system*.
- Naval forces will exploit information technology to network robust, simple, interdependent elements into a nimble, distributed force.
- Organizational distinctions between tactical missions and functions will fade from force command structure, replaced by self-organizing combined arms teams.
- The initiative and responsibility of unit-level commanders will be the most decisive factor in fluid, rapidly developing operations. Unit-level and tactical self-organization will turn battlespace awareness and cooperative engagement into war-winning advantages.

Purpose and Scope

The *Sea-Based Theater Air & Missile Defense Concept* illustrates future operational capabilities for TAMD as an integral element of sea-based combat operations. TAMD is the first warfare area to begin exploiting the promise of network-based warfighting. This concept describes TAMD capabilities for warfighting scenarios from small-scale naval clashes to sustained, high-intensity operations by a fully developed joint force. It describes the transformation of naval TAMD by emerging technology and changing operational concepts, and provides a framework for sea-based TAMD capabilities circa 2015. The concept flows from and supports national and naval policy and strategy, including *Joint Vision 2010*, *Forward…From the Sea*, the *Navy Operational Concept*, and *Operational Maneuver From the Sea*. The consistent theme running through each of these is the clear requirement for greater naval involvement in the battle ashore.

Sea-Based
Theater Air & Missile Defense

Overview

Future U.S. forces must transform themselves in order to master the interrelated changes taking place in the environment, technology, and processes of warfighting. Relentless change will overthrow traditional notions of battlespace, raising new and surprising challenges and altering time-tested practices. Many of these shifts have first become apparent in the problem of theater air and missile defense (TAMD), defined as the protection of U.S. forces and critical interests against theater missiles and aircraft. The burgeoning challenge to U.S. forces from the theater air and missile threat is further magnified when coupled with weapons of mass destruction (WMD). Computer networking and redesigned organizations will give U.S forces a superior capability to operate with unity and decisive speed as platform-based warfighting gives way to network-based warfighting. Unit-level commanders in combined arms teams will "lead from the front" by self-organizing[1] their tactical actions in execution of their mission orders. Battlespace awareness built on a networked information base will help maintain unity of effort by focusing the combined arms teams on the vulnerabilities in the enemy threat system that offer the greatest leverage.

1. Future Battlespace

The complexity, lethality, and speed of operations in future battlespace compel naval forces to develop new warfighting methods. Front line decision-makers will confront fleeting opportunities and sudden challenges, testing their judgment and initiative in fluid, rapidly developing operations. Sea-based maneuver expands the littoral battlespace and enables naval forces to strike deeper and faster than ever before. As naval forces overcome traditional limitations and turn sea-based mobility into an unqualified source of strength, however, the theater air and missile threat stretches the area that must be kept under surveillance and dominated. The geography of the expanded littoral environment further complicates these operations. A variety of landforms, vegetation, cultural features, meteorological conditions, increasing urbanization, and political factors complicate sensor and weapons coverage requirements by offering covered avenues of approach to air and missile attack. The threat from theater missiles and aircraft is a principal factor in the expansion of active battlespace to cross-continental ranges and into the exoatmosphere. Defenses must destroy low-signature unmanned air vehicles, counter fifth generation piloted aircraft, defeat terrain-hugging cruise missiles, and intercept ballistic missiles in space. U.S. forces must degrade or prevent enemy aerial and spaceborne reconnaissance and hostile intelligence collection across the electromagnetic spectrum. The sheer extent of the battlespace defies even space-based and high altitude surveillance systems, particularly when the enemy can launch an attack from thousands of kilometers away. This environment places a premium on clear guidance, extensive training, and information superiority for force protection.

[1] "Self-organization" is a characteristic of basic units making up complex systems. For network-based TAMD, it identifies how commanders cooperatively utilize the collective capabilities of multi-mission-capable units and systems. Just as platform-centered command and control systems organize tactical control of *units*, network-based command and control systems organize netting of *capabilities,*enabling unit commanders to make the most of the units they lead.

2. Sea-Based Forces

The geopolitical environment is undergoing fundamental redefinition in several dimensions. The end of the Cold War has unmasked a world of interrelated, conflicting strategic competitions between regional powers in several parts of the globe. As the number of overseas bases for US forces declines, the emerging geopolitical environment places a premium on forward presence and sea-based forces able to lead ad hoc coalitions when a crisis or conflict erupts. Political conditions may require future operations to steer clear of neutral airspace and territory, respond to the different concerns of coalition and alliance partners, and blend U.S. objectives with those of its partners. Tactical operations mirror these problems, often resulting in different rules of engagement for the components of a multinational force.

Developing sea-based capabilities for ship-to-objective maneuver, deep strike, and long-range interdiction are recasting the littoral battlespace, stretching it far to seaward and deep into enemy territory. Sea-based forces will drive past the high water mark deep into inland areas, speeding the tempo of battle without exposing the force to unacceptable levels of risk. Network-based naval forces integrate mutually supportive operations, sharing battlespace between strike, maneuver, and force protection elements. Naval forces are the expeditionary vanguard for joint forces in an expeditionary environment, but they are integral to any joint force. Naval forces provide power projection, sustainment, and uninterrupted force protection from the air and missile threat at sea and ashore. The sea-based elements of the joint C4I network are the foundation of a joint "plug and fight" architecture, smoothly incorporating each new unit as it arrives, and speeding maneuver without compromising security. "Plug and fight" interoperability means that anyone can use data from any source in the network. Units no longer are limited to Service-specific sensor types and data links, and they can rapidly enter and leave the dynamic, adaptive network architecture.

2.1 Shape the Battlespace, Seize the Initiative

Naval forces aim to seize and retain the initiative, compelling the enemy to fight on terms that offset his strengths and favor the U.S. force. This is especially important in theater air and missile defense. Every operation involves tradeoffs, pitting the available forces against the points that offer the most leverage against the enemy theater air and missile system. Theater air and missile defense has both offensive and defensive aspects - the best defense usually is spearheaded by focused offensive action. At the operational level, TAMD relies on offensive action as much as on defensive operations. This is exemplified in the four operational elements contributing to TAMD:

- *Attack operations* - direct attack against aircraft and theater missiles before they become airborne, and indirect attack through strikes on their supporting systems.
- *Active defense* - operations to destroy aircraft and theater missiles in flight.
- *Passive defense* - measures to prevent attack, minimize the effects of attack, and to recover from attack by aircraft and theater missiles.
- *C4I* – systems that coordinate and integrate force capabilities to conduct and link passive defense, active defense, and attack operations.

The four operational elements are not tactical organizations, nor do they alter the chain of command. They are terms for mutually supportive joint capabilities and functions in the mission of TAMD. Just as these elements blend at the operational level for planning and assessment, so must TAMD blend with other combat operations by multi-mission units at the tactical level.

3. The Future Threat System

The increasing speed, range, and lethality of the theater air and missile threat heighten the danger for U.S. forces. When hostile theater missiles[2] and aircraft are armed with weapons of mass destruction[3] (WMD), the threat is even greater. Despite the importance of defeating this threat, the proliferation of sophisticated technology makes it even more difficult to prevent or counter. Each future adversary will bring a unique combination of strategy, geography, forces, culture, infrastructure, tactics, and command and control to the battle. This uncertain, evolving threat highlights the increasing availability of advanced weapons and supporting systems to cash-carrying customers. It also signals the spread of capabilities for indigenous production or modification of advanced weapons systems and enabling technologies. Proliferating weapons systems include theater ballistic missiles, land attack cruise missiles, advanced air-launched weapons, fifth generation combat aircraft, electronic warfare systems, and WMD. While the danger posed by WMD is unquestioned, the danger from every attack by conventional, precision-guided munitions will increase as adversaries take advantage of GPS-like navigation systems, multi-mode seekers, and improved targeting support and target acquisition systems. Unmanned aerial vehicles (UAV) and commercial access to space-based surveillance imagery will make it harder for U.S. forces to deny hostile intelligence, reconnaissance, surveillance, and targeting capabilities.

Whether armed with conventional warheads or with WMD, manned strike aircraft and theater missiles will continue to compress the time available to detect and defeat them. Air and missile threats exploiting terrain-hugging cruise flight or exoatmospheric ballistic flight will continue to press at the limits of U.S. capability to detect, engage, and neutralize them. Hostile aircraft and missiles will become harder to detect and engage as they exploit radar and infrared signature reduction technology. Even less-developed air forces will employ decoys, penetration aids, and other advanced countermeasures. Cellular and digital communications systems will make it harder for U.S. forces to exploit, disrupt, or deceive hostile command and control. Although advanced strike aircraft are increasingly available to the world arms market, many nations now rely on theater missiles for a powerful strike capability to avoid the maintenance, infrastructure, and aircrew proficiency problems attendant to manned strike aircraft. Future adversaries will employ larger raids and coordinated attacks rather than the single missile raids characterizing many past operations. For manned aircraft and theater missiles, the heaviest attacks are likely to be in the first days of future conflicts as the enemy seeks to neutralize key elements in the defense and to bar the arrival of reinforcements. This is when U.S. forces are likely to be at their lowest strength, elevating the importance of attack operations against the hostile theater air and missile system. Even here the adversary is becoming difficult to counter as logistics support and operating infrastructure become increasingly mobile and dispersed, less cumbersome, and easier to camouflage or conceal.

4. Network-Based Warfighting

If they are to increase their warfighting effectiveness, naval forces must transform their operations and organization to realize the full benefits in emerging technology. Individual platforms will be netted as a distributed entity – a "system of systems" enabling tactical combat leaders to lead self-organized operations making the most of collective capabilities. Naval forces will combine and recombine their integrated sensors and weapon systems in dynamically adaptive force operations that cooperatively apply their individual capabilities in networked collaboration. Human decisions will determine how, when, and why

[2] Theater missiles are "ballistic missiles, cruise missiles, and air to surface missiles whose targets are within a theater of operations" but exclude battlefield, direct-fire weapons (Joint Pub 3-01.5, Doctrine for Joint Theater Missile Defense).

[3] "Weapons of mass destruction" include nuclear, biological, and chemical weapons.

the systems in the network exchange sensor, weapons, and decision signals, and what they do in response. Some of these decisions will take the form of automated "doctrine statements"[4] – groups of algorithms chosen to frame how automated systems route, process, and react to data or signals. Commanders will determine how the network should be set up and how operations will be controlled to ensure effective command and control. Combat leaders will be assisted through network-generated force orders recommendations, engagement coordination advisories, and support for remote engagement (the ability of a third party to direct the weapons of another "shooter".) Like nuclear weapons, networking is a powerful force for change in warfighting organization, planning, command and control, operational concepts, and tactics. Four fundamental shifts underscore the importance of networking to sea-based theater air and missile defense.

- Operations will be increasingly collaborative as combat units increase their ability to integrate their actions and collective capabilities, supported by signal exchanges between automation-assisted combat systems.
- The forward-most commanders, those directly engaged in combat, will assume the decisive role as "battlespace awareness" exponentially increases their ability to understand what must be done. Unit-level commanders will act effectively in concert as a battle group and independent units will no longer act in isolation.
- Distributed network elements with battlespace awareness will collaborate in the intelligence preparation of the battlespace (IPB) process, crafting a continually improving and penetrating analysis of the situation that is inseparable from force operations.
- Networking frees operations and planning from mission area stovepipes. Tactical commanders will fight all their missions simultaneously in integrated battlespace that dispenses with the restrictions imposed by traditional battlespace geometry.

Front line combatants have always had the most immediate feedback and knowledge about the tactical situation but have never had timely access to the context and meaning of "the big picture". Now they will, using the network to revolutionize operations throughout the battlespace. Networking will shift the emphasis in combat decision-making forward and down. By reducing the number of intermediate commanders and establishing greater clarity in the division of labor between the levels of command, networking will enable the people operating the combat systems to act more quickly and effectively than ever before.

4.1 Integrated C4I

Integrated C4I systems connects national, theater, and component sensors with intelligence nodes and non-tactical information sources in an integrated architecture. This architecture is the foundation of the network and provides every level of the chain of command with access to netted information from distributed nodes. "Plug and fight" interoperability enables units to rapidly and smoothly integrate into the force by eliminating interruptions at interfaces for manual handling, translation, or that compromise the quality of data as it is exchanged between systems. Standard formatting, exchange protocols, and entries will streamline information composition, fusion, and correlation. The network provides dynamic paths for multi-casting distinct classes of complementary, mutually supportive data to distributed users with different purposes. These data classes include:

- Real time netting of sensor measurement data, combat system signals, and decision support system signals at the unit-level

[4] "Doctrine statements" in this sense are the algorithms selected to control operations of an automated system such as the AEGIS Weapons System or the Cooperative Engagement Capability. They are not "doctrine" in the formal meaning of the word.

- Near-real time exchange of track data, force orders, tactical intelligence data, and status reports at the unit and tactical levels
- Non-real time exchange of force-level status reports, intelligence information, and supporting data from the theater and component levels down to the tactical and unit levels.

Automation of simple, mundane handling, routing, and calculation tasks enhances multi-directional communications flows. Integrated C4I increases the proportion of time people spend evaluating and acting on information instead of searching for, collecting, and sorting information. Unit-level sensor netting is indirectly distributed to the whole force through incorporation in near-real time data flows, improving the continuity, quality, and certainty of the surveillance picture. Similarly, unit-level exchange of netted combat system and decision support signals improves force coordination and battle management indirectly through incorporation into near-real time exchanges of force orders and status reports. Operational nodes tap this information flow for situational awareness, assessment, and planning, but they combine it with non-real time information that supports operational level decision-making. Concurrently, operational level nodes send intelligence information, operational guidance, logistics information, plans, and sensor data from national and theater level sources into the information base for use by forces at the tactical and unit-levels.

Durability / Robustness

Netting turns dispersion into an advantage by preserving the effects of mass while increasing the extent and quality of surveillance and force protection. The self-organizing nature of network-based systems provides superior casualty control and resistance to degradation. Netted systems adjust sensor assignments in response to equipment casualties, down periods for movement, or battle damage. Robust communications, overlapping surveillance capabilities, and layered defenses will be coordinated and maintained through self-healing C4I networks that overcome loss or degradation of individual nodes during combat. In extreme cases, the network gracefully degrades to alternate systems and casualty modes of operation to retain the greatest possible system capability even as it executes measures for recovery and reconstitution. The network itself will assist with the identification of combat losses or casualties to its elements and advise commanders how best to adapt the system to their needs until recovery is complete.

4.2 Battlespace Awareness

Network-based forces turn information integration and information superiority into battlespace awareness - the capability to ensure every point in the force has an *effective* and *coherent* understanding of what has happened, what is happening, what can happen, and what to do. Coherence means there is harmony between each unit's perception of the situation. It also means there is harmony between the perceptions of the operational, tactical, and unit-level echelons in the chain of command despite the differences in *what* they display and how. Coherence harmonizes and even exploits the inevitable, often desirable differences in information at each node in the force, but it is only possible because there is common access to integrated information. Battlespace awareness includes the whole picture of combat, not just the "air picture", "surface picture" or any other "picture" limited to a single mission or function. The ability to deal with uncertainty, ambiguity, and inconsistency is an essential quality of battlespace awareness. In battle, time is critical and information is incomplete: knowing enough to make a timely, good decision is more important than finding a better solution when it's too late. Battlespace awareness depends on training, experience, planning, and judgment every bit as much as on powerful sensors and integrated, relational databases.

Battlespace awareness comes from integrated information. Information and data from national, theater, and component sensors and nodes is dynamically organized in an integrated information base via the integrated C4I infrastructure. This developing information base includes intelligence information and non-tactical

supporting information such as climatological, geodetic, or economic data. Each user in the force must see the information in a manner tailored to their function and mission to enhance rapid interpretation and decision. Multimedia presentation is one part of the answer, but the real power of networked, integrated information lies in displaying its *meaning* as enriched, compounded *knowledge*. Data and information become knowledge through analysis, synthesis, and evaluation. The picture will present integrated information in a dynamic, customizable presentation of the current situation with access to supporting data. By integrating the information from each node, the network enriches the information base, building battlespace awareness from real time, near-real time, and non-real time information. In turn, decision-makers and their automated intelligent assistants can send feedback to the sensor networks, redirecting force sensors to clarify ambiguity and inconsistency, and to reduce uncertainty.

4.3 Tools and Doctrine

Computers able to work with complex problems in tactically useful timelines will host previously unavailable planning tools. Intelligent agents and expert systems will help staffs at distributed sites develop requirements, propose possible courses of action, and evaluate the best courses of action. Expert systems and intelligent agents for battle management will automatically act to identify, investigate, and help resolve ambiguity, disagreement, and uncertainty. Extremely powerful computers applying general principles and ideas about the order underlying "chaotic" systems will enable us to work with previously unmanageable problems. Although they previously defied conventional, iterative analysis and brute force computation, military operations are an extremely promising realm for application of complexity theory. Without implying that combat can be "solved", decision-makers still need analytical tools for planning, decision support, and assessment using a dynamic information base. Most of these tools will employ traditional logic, but many intelligent agents and expert systems will apply "fuzzy logic" to imprecise, ambiguous, and inconsistent information - just as people do - learning by correlating perceived similarities in observations and ideas. These tools must employ compatible algorithms and processes, and the operators must work from mutually supportive assumptions in order to arrive at coherent results. Many planning tools will feature embedded modeling and simulation capabilities. Planners will be able to run information age "rock drills" to develop and try out planned responses to battlespace developments. These capabilities will be invaluable during analysis and assessment of operations to evaluate critical areas for improvement. Planners will be able to develop, visualize, and test the system of algorithms and rules statements making up the interrelated, automated system doctrines for the sensor nets, integrated combat systems, and communications networks.

4.4 Netted Combat Operations

Characterization of specific actions and missions as "offensive" or "defensive" will be less clear and less useful. Attack operations will indirectly support active and passive defenses by pressuring enemy theater air and missile forces at key points within reach of U.S. capabilities and objectives. Where they are unable to prevent theater air and missile raids, attack operations may still degrade enemy operations. Active defenses will engage hostile aircraft and theater missiles in successive layers of defense that combine theater-wide, area, and point defense capabilities from the exoatmosphere to the surface. Active defenses providing 360-degree coverage will be enhanced by high-confidence combat identification capabilities that enable them to conduct beyond-visual range (BVR) engagements to the full kinematic capabilities of electronic attack, directed energy, and missile systems. Complementary engagement tactics will use more than one type of weapon system to engage the same targets or even entire raids. Cooperative tactics combining different, mutually supportive weapons and sensors will improve defensive effectiveness against many hostile countermeasures. Network-based indications and warning for force protection and civil defense will be more timely for the forces threatened by hostile air and missile attack, and it will also be more exact and

appropriate as capabilities for calculating threatened areas improve. This will eliminate losses to force effectiveness from unnecessary adoption of protective posture and measures, particularly for WMD threats. Passive defenses will also be improved by network-enhanced capabilities to exploit sea-basing, mobility, and operations in dispersed formations.

4.4.1 Sensor Netting, Cooperative Engagement, & Cooperative Decision

The network connects weapons, sensors, and combat decision systems aboard aircraft, ships, and land-based systems. Individual aircraft, ships, and ground units will be netted into a distributed entity capable of collaborative action in battle. Powerful new sensor systems will scan and probe every electromagnetic avenue in the battlespace from spacecraft, UAV, piloted aircraft, ships, land vehicles, and unattended ground sensors. Sensor coordination creates a division of labor among the surveillance assets available to the force, focusing each on specific search volumes to develop the most complete coverage of the battlespace. In its fullest sense, sensor coordination integrates data from complementary, dissimilar systems covering the entire electromagnetic spectrum. The network provides positive identification and tracking of friendly, neutral, and hostile units by compositing sensor data and fusing tactical information, aided by automatic target recognition systems and non-cooperative target recognition capabilities. Sensor data fusion combines data from dissimilar but complementary sensors into the integrated information base supporting battlespace awareness. Sensor cooperation will deny cover to enemy aircraft and missiles attempting to make a masked approach, and airborne surveillance systems will be able to take control and direct air-to-air missiles and SAMs fired against targets which the shooters themselves cannot track with their own sensors. Fire control systems cued by networked sensors will immediately acquire cruise missiles and low-flying aircraft as they emerge from covering terrain or weather, engaging them with smart-projectile gunnery, directed energy weapons, and missiles. Network functions will include provision of warning and cueing information to ground-based, unit-level self-defense systems. Sensor cooperation will help defenders overcome jamming, distinguish decoys from true threats, and neutralize other countermeasures.

Netted, composite information developed between cooperating units will alert operators to what other units are doing, help identify priority targets, recommend target-firing unit pairings, and provide tactical warnings and advisories as the battle progresses. The exchange of weapon and sensor system signals between cooperating units in the network will allow the netted combat systems to exchange actions and intentions between each node in the net. The ability of front-line decision-makers to act in concert via direct communications between themselves will be enhanced through the networked exchange of weapons, sensor, and decision support system data between the combat systems in the force network. The network itself is an integrated system of integrated combat systems (like the Aegis Weapons System, the Ship's Self-Defense System, or the Automated Combat Direction System[5]). This network is a complex system operating in accordance with a dynamic set of interdependent, automated system doctrine statements designed to support human decision-making and action. Embedded expert systems alert operators when they recognize enemy attack patterns or tactics, rapidly calculating recommended courses of action and prompting operators with planned responses through cues in the situational awareness display. Active cooperation between the nodes leads to coherent recommendations for engagement priorities, weapon-target pairings, and other combat information despite simultaneous calculation at each unit. Networked combat systems will help decision makers balance sensor coverage, overlapping engagement envelopes, probabilities of kill, suitable target-weapon pairings, weapons availability, reload capabilities, on-station time, and self-defense capabilities in the functions of battle management and tactical combat. The network will support improvements to the

[5] Aircraft also are integrated combat systems, but they will incorporate significant increases in automated support to their aircrews, including features such as automated target recognition/extraction systems and counter-counter measures that will require careful coordination of operating algorithms or "system doctrine."

speed and quality of decisions about best responses, helping commanders organize and evaluate reports, time constraints, available assets, prioritized targets, and the trade-offs involved in engagements. Traditional tactics based on the actions of individual platforms fighting independent engagements will yield to cooperative tactics integrating complementary, often dissimilar capabilities among networked units.

4.4.2 Command and Control

Networked battlespace awareness will give the commander an accurate, timely understanding of the current situation that enhances his ability to synchronize the actions of the force. Men still fight and command battles, and the network is designed to improve their ability to exercise command and control in the disorder and complexity of warfare. Commanders try to maintain purpose and give direction to events, but complex systems interacting in unexpected ways often lead to logical yet unforeseen consequences. Modern warfighting operations are complex, interdependent processes that are poorly suited to inflexible, hierarchical systems and detailed, linear plans. In complex, non-linear processes like warfighting, small changes at one level can have a big impact at the same or different levels by disrupting or even stopping tightly linked operations and organizations. Adaptive, self-organizing forces conducting operations from the "bottom-up" are better able to execute a dynamic plan in a complex, developing environment. Tactical operations will become increasingly self-organized within the bounds set by guidance from higher authority. Command and control for a network-based force increases the reliance on doctrine, training, and experience in order to effectively use the battlespace awareness and cooperative capabilities created with the network.

Netted command and control is faster and more effective than a traditional, sequential command and control process. It replaces the "back and forth" flow coordinated atop separate, vertical chains of command with netted communications and coordination. As specialized data and communications for compartmented warfare areas or missions fade away, the network provides information about interdependent warfighting missions and enhances the power of unit commanders who have always been multi-mission warfighters. Some operational planning and assessment may focus on conceptually discrete problems in force operations, but specialization in information and communications fades at the tactical and unit levels of warfighting. In every situation, automated support assists human decision-making. At the lowest, most immediate level of combat, automation helps commanders evaluate the specific factors in each engagement or strike at the unit level. At the tactical level, automated support should help balance the individual engagement with action required against the raid(s) or strike targets, and with competing requirements from other missions. Automated support for the operational commander should help assess the significance of a raid or the progress of a strike in the context of the ongoing situation in the theater. The role of the operational and tactical staffs is crucial in the design, testing, promulgation, and adaptation of continuously developing systems of automated doctrine for the network of integrated combat systems. This collaborative effort creates a dynamic, complex system of interdependent, automated system doctrine statements designed to support human decision-making and action in execution of the commander's intent.

Unit-Level Command: Cooperative Engagement and Cooperative Decision

Unit-level commanders and tactical operations are the most decisive level of network-based warfighting. Battlespace awareness catalyzes the ability of small unit commanders to implement commander's intent, using their initiative to lead self-organizing tactical operations in the battlespace shaped by the operational commanders. Unit commanders rely on their judgement and initiative to achieve the commander's intent and grasp victory in the fluidity and confusion of the tactical situation. Netted exchange of individual actions and judgements between unit commanders creates lateral and vertical coherence in a dynamic situation. This bottom-up feedback drives adaptation to the commander's plan in an asynchronous,

collaborative process that links engagements, raids, and battles to the campaign, and integrates theater air and missile defense with other operations. This unit-level exchange will filter up through every level of command, allowing the force to act with greater speed and stronger, more flexible unity of purpose than would be possible in a top-down, centrally directed force. Integrated action at the unit level will diffuse upward and outward throughout the force, guided by force orders and control by negation. Commanders issue force orders when they need to initiate, redirect, or stop action by one or more elements of a networked force.

Tactical Command: Control, Coordination, and Management of Capabilities

Tactical commanders monitor and manage the battles, maintain the network effectiveness, and direct operations. Tactical commanders will have the capability to rapidly redirect tactical control of capabilities resident in multi-mission units between concurrent missions while they oversee development of near-real time and real time components of battlespace awareness. Netted linkages between tactical commanders, surveillance, and combat forces will support the battlespace awareness needed to sustain faster, decisive action in collaborative, self-organizing operations. Tactical commanders will exercise control by negation over self-organizing tactical forces acting within the bounds set by the commander. They will exercise authority over *capabilities* as much – or more than – they exercise authority over units or formations. Force orders and netted cooperation both come to bear in the direction of battle, in proportions that shift with the situation and conditions. Human judgment will benefit from automated recommendations to handle the complex, interdependent factors involved in combat decisions.

Operational Command: Planning, Force Management, & Operations Assessment

Operational command stays ahead of the battles, focusing on the longer-term, continuous processes of campaign planning, shaping the battlespace, and assessing the progress of the campaign. Their most immediate concern is to set the stage and conditions that enable tactical commanders to achieve assigned objectives. Operational commanders organize force priorities, delegate authority over force capabilities, and prioritize access to force capabilities. Basic decisions and interpretations implementing the commander's guidance are embodied in the overall constraints and requirements for the force and the network set by the commander. Operational commanders retain full authority over force operations, but normally restrain themselves to monitoring the situation and the exercise of control by negation. They are the final control points during battle, intervening only when necessary to exploit success or shore up problems. When circumstances dictate tight, central control of the force, such as during a tense military confrontation prior to hostilities, the network supports direct control of combat forces by the operational commander.

4.4.3 Distributed, Collaborative Planning

Network-based battlespace awareness enables collaboration during the planning process at every level of the chain of command and helps integrate operations within the force. In turn, planning feeds back into battlespace awareness by setting the context for understanding force operations and the situation. The commander's estimate and operational guidance set the objectives and the manner by which they should be achieved. Planners use the methods of IPB to identify the possible courses of action open to the force and to the enemy as an integral part of the operations process. Mission orders identify the course of action selected by the commander and set out the objectives for each subordinate commander. The commander monitors the progress of the battle, using combat feedback from subordinates to dynamically adjust the plan to take advantage of success and counteract problems. The increased "bottom-up" contributions of the tactical details leave the commander's staff more time to focus on assessment and shaping the battle. The collaborative IPB process integrates parallel efforts throughout the chain of command, taking advantage of

all available resources and expertise. Using integrated information and compatible tools, distributed, collaborative planning fosters netted exchange of IPB products. Network-based operations will speed the processes of developing plans for execution and adapting plans during execution, blurring the distinction. IPB becomes less cyclical, taking the shape of a self-organizing give and take between the participants, increasing the overall rate of development. Surveillance and reconnaissance information by networked systems continuously updates joint force IPB. Timelier, higher quality battle damage assessment and analysis information is rapidly incorporated into the IPB process, improving overall force battlespace awareness and planning. IPB integrates preceding information and ongoing assessments into force plans. The commander and his staff lead and control the collaborative IPB process. Upon approval of changes by the commander, the staff assigns the metadata[6] used for "version control" of planning products. The network-based process eliminates delays caused by sequential reporting up the chain of command, as well as the time lag before information is assimilated, and returned from the top. The "centralized" planning process actually serves, therefore, to enhance decentralized execution of the planning process, subject to the approval of the commander.

Summary

Naval forces are the sea-based element of the joint network. During enabling operations they are the entering wedge for the joint force and provide the foundation of the joint "plug and fight" C4I architecture, supporting joint interoperability throughout a developing operation. Because sea-based forces are fully engaged in the land battle from start to finish, they provide power projection and force protection throughout integrated battlespace. Sea-based forces operating in dispersed formations maneuver at speed to attain their objectives and forestall enemy counterattacks. Sea-based forces must hit faster, more accurately, and more decisively than the enemy in order to seize the initiative and control the terms of battle. Networking increases force protection through battlespace awareness, cooperative decision, and cooperative engagement. Network-based TAMD requires new technology, tactics, systems, training, and organization. Combat organization will adapt to the new way of warfare, reflecting the redefinition of tactical command and control. While increasing the ability of the force to build timely, accurate, and shared understanding of the situation, the network also promotes the ability of commanders to anticipate and understand one another's actions. The design, construction, and training of network-based forces should play directly to traditional U.S. strengths, capitalizing on such qualities as self-organization, teamwork, and collaboration.

[6] "Metadata" is information distinguishing information. Familiar forms in everyday use include identification of the source, summarization of content, date of creation, etc.

Future Operational Capabilities

Future TAMD Capabilities

The *Sea-Based Theater Air & Missile Defense Concept* is a naval solution to the best use of network-based Navy and Marine forces in TAMD. It illustrates and develops the full measure of the naval contribution to joint, integrated TAMD. Network-based TAMD depends on tested, carefully coordinated changes in doctrine, training, organization, leadership development, software, and hardware. Despite the lack of a unifying framework, some of these changes are already underway. Other changes have yet to be identified and started, a process this concept is intended to support and guide.

Doctrine

Doctrine development should create top-level, guiding principles for use by operational forces and program managers. Doctrine development should harmonize development of network-based TAMD, making the most of each Service's forces, training, and equipment in pursuit of a common objective. Common doctrine supports cohesive operations, enabling joint forces to fully exploit emerging ideas and technology. TAMD doctrine should unify joint and naval doctrine with ideas emerging from Joint Vision 2010 and Service vision statements. Because naval forces and systems are joint in function and operation, their capabilities provide the foundation for a joint task force, promoting uninterrupted development as reinforcements arrive in the theater. The distinction between "offensive" and "defensive" actions, systems, and missions is of decreasing utility, and doctrine should reflect this increasing integration. Future doctrine must identify and develop:

- Changes in force combat organizations and staffing;
- Responsibilities, duties, and tasks for the nodes in the command structure;
- Guidance for integrating power projection and force protection capabilities into combined arms teams;
- Guidance for concurrent operations in integrated battlespace, synchronizing TAMD operations with other network-based warfighting operations;
- Processes and products used during distributed, collaborative planning;
- Cooperative engagement between dissimilar forces and systems.

Training

Network-based TAMD requires adjustments to naval training and personnel programs. Naval programs must unify the Navy and Marines while flexibly accommodating Service-unique requirements. Naval programs should be familiar and easily understood by students from other Services and allied forces. Personnel programming will respond to reduced manning requirements resulting from the application of developing systems, emerging doctrine, and reorganization for network-based warfighting. Training and professional education must develop operational and tactical thinking about how to manage and operate with network-based forces while improving understanding of the threat as a system. Specific issues for naval training and personnel programs include training, manning, and qualifying:

- Staffs and units for network-based operations and collaborative planning;
- Staffs and units for combined arms training opportunities - particularly through war gaming and simulation - within the naval forces, and with joint forces;
- Staffs and watchstanders for cooperative engagement, sensor netting, and cooperative decision;
- Staffs and units for experimentation in advanced training environments, enabling experienced fleet operators to try new tactics, adopt new weapons, and explore the capabilities of all systems;
- Watchstanders and staff planners in Service-specific and joint doctrine in a realistic environment that allows trainees to learn by doing;
- Joint Interface Control Officers (JICO) and J6/N6 personnel at the joint force, Fleet, and command levels - people with formalized expertise in C4I integration who are able to develop, test, and evaluate network setup and interactions of automated systems doctrine;
- Watchstanders and staffs to work in dynamic situations, helping them learn to make effective, correct decisions despite ambiguity, disagreement, and uncertainty in information;
- Watchstanders and staff officers to recognize driving factors in designing and changing force networks, including management of casualties to the network;
- Individuals in self-organized tactical operations during individual and unit training exercises.

Leadership

Leader development for network-based forces drives towards a different way of thinking about combat. The leaders of a network-based force cannot afford to think in traditional terms. They must be able to think and act in dynamic, non-linear situations where their attention is continually pulled in competing directions. Future leaders must:

- Possess and cultivate knowledge, intelligence, and presence of mind during fast-developing operations in complex environments;
- Practice and master the skills of tactical self-organization and lateral integration that are crucial to exercising initiative and executing mission orders;
- Master the technology of the network as well as they understand the individual systems and Service tactics, techniques, and procedures;
- Practice and develop skills in collaborative planning and cooperative decision;
- Possess a mastery of joint operations and capabilities.

Organization

Combat organization must adapt to the operations and design of the networked force and its capabilities. Hierarchy will not disappear, nor will it simply become flatter. Inefficient nodes must be removed from the organization. Specialized nodes and supporting functions such as intelligence must be incorporated into operational decision-making centers and integrated support centers, smoothly networking into operational processes. Operational organization must become more adaptive, recombining different elements to make the most of the forces and capabilities available to the commander. The traditional carrier battlegroup may not be the only standard for the basic unit of Navy organization and deployment. Network-based forces

must be designed as self-contained, autonomous organizations that can be deployed and used as central elements of a naval or joint task force. The designs for these organizations should incorporate support from external organizations and structures, providing access to expertise and resources in a "virtual staff". Administrative organization also will adapt to changing force structure, technology, and operations. Organizational changes should reflect:

- Operational choices underlying the design of the integrated C4I network;
- Capabilities and processes for distributed, collaborative planning;
- Increased emphasis on unit-level initiative and self-organization between tactical leaders;
- Self-organized operations by combined arms teams;
- Response of command and control structure to fully leverage automation;
- Rethinking and consolidating the enlisted ratings structure as distinctions between operators and maintainers blur and systems migrate to common equipment.

Equipment

Equipment for network-based forces includes development of suitable hardware and software. Functions and capabilities must continue to migrate into integrated equipment and processes. Development and uniform implementation of interoperability standards by each Service are essential first steps. These standards require a controlled process of continuing, coordinated upgrades to maintain peak performance by network-based forces. The defense industry must take steps to design interoperability into their products prior to the negotiation of contracts and be prepared to adapt to refinement of requirements as development proceeds. Specific desired capabilities include:

Information Integration

- A networked information base that pools and synthesizes heterogeneous information from all sources for intelligent push and user-pull by all users;
- Presentation systems that focus the user and intelligent agents on customizable, dynamic evaluations of information with links to supporting information;
- Systems to identify and resolve ambiguous, conflicting, and uncertain information;
- Tactical information products that support reconfiguration into different presentations and forms of display, and that can be integrated with information from other sources;
- Integrating supporting information and data such as meteorology, mapping, charting, and geodesy, and logistics into the network information base;
- Standard protocols, operating environments, algorithms, and communications formats;
- Applying artificial intelligence to routine handling and processing tasks so operators can focus on content, meaning, and decision;

Tools

- Tactical decision aids embedded in combat and presentation systems;

- Tools for designing, developing, and maintaining force C4ISR networks and their sub-nets, including tools for sensor netting;
- Visualization tools for developing and testing force automated systems doctrine and automated subsystem doctrines;
- Collaborative planning tools working with networked information synchronizing operational, tactical, and unit-level planning and preparations;

Combat Systems

- Cooperative signal processing between dissimilar sensor systems;
- High-confidence combat identification capabilities supporting BVR engagement by surface-to-air and air-to-air weapons;
- Detection and engagement capabilities against terrain-following cruise missiles;
- Naval combat systems capable of cooperative operations as components of a network-based force;
- Compatible implementations of automated system doctrines between different platform types;
- Cooperative engagement capabilities between dissimilar weapons systems;
- Ascent-phase intercept capability against theater ballistic missiles;
- Capabilities to locate and destroy mobile missile systems on the ground and at sea;
- Detection and engagement capabilities against reduced signature aircraft and missiles;
- Electronic attack against aircraft and theater missile's targeting and guidance systems;
- Underway rapid reload capabilities for TAMD weapons;
- Electro-magnetic pulse protection for combat systems and the network.

Conclusion & Recommendations

Conclusion

Future naval readiness for prompt and sustained combat operations will extend well beyond the traditional concept of the shoreline. Sea-based forces will complicate the enemy's intelligence, surveillance, and reconnaissance through mobility, speed, and deception. Maneuvering from the sea directly to objectives ashore, naval forces will force the enemy to spread out his defenses while naval forces maintain their concentration and focus. This relative magnification of naval strength, coupled with the ability to strike hundreds of kilometers inland from positions well beyond the horizon, will create a speed of attack that compresses the enemy's time for reaction. Sea-based fires and air and missile defenses will protect strike and maneuver forces operating deep in enemy territory. Naval forces are fully interoperable with the other services in tactics and technology, forming an invaluable element in any joint task force and often serving as the first element on-scene in the U.S. response to any crisis.

Networking is the most powerful force for change in modern warfare, compelling reorganization of combat forces and moving the locus of tactical decision-making forward and down. Networks promote effective naval operations by reinforcing the strengths of dispersed, fast moving forces. Unity of effort and economy of force focus the power of naval forces at the decisive place at the right time. This focus directly results from self-organizing tactical forces conducting network-based operations. Networking is the combat multiplier that magnifies and catalyzes other technological advantages emerging from U.S. research and development activities. The power of naval forces increases as they reap the harvest of emerging technology and increasing interoperability. New operational concepts and technology are not the only catalyst to change, however, for the increasing threat from theater missiles and aircraft is proliferating around the globe. This emerging threat reduces reaction time for defensive action whether the attack is from theater ballistic missiles crossing thousands of kilometers, supersonic strike aircraft and air-to-ground missiles, or terrain-hugging cruise missiles. This arsenal expands the battlespace that must be kept under surveillance in readiness for prompt engagement. More than ever, timely, decisive action is an essential element of theater air and missile defense.

Recommendations

Development of network-based theater air and missile defense capabilities depends on a concept-driven system of experimentation and implementation. This is the most promising means of addressing the key issues and questions in network-based TAMD. It is recommended that:

- Naval leadership should commit to developing a joint-interoperable, mission-interoperable naval TAMD capability.
- The *Sea-Based Theater Air and Missile Defense Concept* should be used to develop a roadmap for naval experimentation, testing, and implementation of network-based TAMD.
- The roadmap must be dynamic, using analysis, seminars, modeling and simulation, wargaming, and fleet battle experimentation to test the future operational capabilities of the concept, as well as the choices and assumptions guiding development of the network-based system.

- The research and development community should identify standards and means to integrate tactical and non-tactical into the information base for battlespace awareness and IPB.
- Design of the information base and C4I architecture must identify facets that are unique to TAMD, but design “hooks” for other missions in the joint architecture.
- Joint and naval experimentation must develop tactics and technology for integrated engagement.
- U.S. forces must improve their training and capabilities to deny targeting information to the enemy theater air and missile system.
- Decoy identification and discrimination capabilities must be improved, as well as capabilities for automated target recognition and automated target extraction.
- Research must be stepped up in improving future training and readiness, especially in training people to execute self-organized tactical operations in fast-developing situations.